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TITLE OF INVENTION

INTERLEAVE ADDRESS GENERATION APPARATUS AND INTERLEAVE ADDRESS GENERATION METHOD

APPLICANT(S) FOR DO/EO/US

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Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (24) indicated below.
4. ☐ The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C. 371 (c) (2))
 - a. ☐ is attached hereto (required only if not communicated by the International Bureau).
 - b. ☒ has been communicated by the International Bureau.
 - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
 - a. ☒ is attached hereto.
 - b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
7. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3))
 - a. ☐ are attached hereto (required only if not communicated by the International Bureau).
 - b. ☐ have been communicated by the International Bureau.
 - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
 - d. ☐ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)).
10. ☐ An English language translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).
11. ☐ A copy of the International Preliminary Examination Report (PCT/IPEA/409).
12. ☒ A copy of the International Search Report (PCT/ISA/210).

Items 13 to 20 below concern document(s) or information included:

13. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
14. ☒ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
15. ☐ A **FIRST** preliminary amendment.
16. ☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
17. ☐ A substitute specification.
18. ☐ A change of power of attorney and/or address letter.
19. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.
20. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).
21. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
22. ☐ Certificate of Mailing by Express Mail
23. ☒ Other items or information:

Claim for Priority with PCT/IB/304

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24. The following fees are submitted:.

BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :

- ☐ Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO **\$1000.00**
- ☒ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO **\$860.00**
- ☐ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO **\$710.00**
- ☐ International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) **\$690.00**
- ☐ International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) **\$100.00**

ENTER APPROPRIATE BASIC FEE AMOUNT =**\$860.00**Surcharge of **\$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (e)).**\$0.00**

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE
Total claims	13 - 20 =	0	x \$18.00
Independent claims	9 - 3 =	6	x \$80.00

\$0.00**\$480.00**Multiple Dependent Claims (check if applicable). ☐**\$0.00****TOTAL OF ABOVE CALCULATIONS =****\$1,340.00**☐ Applicant claims small entity status. (See 37 CFR 1.27). The fees indicated above are reduced by 1/2.**\$0.00****SUBTOTAL =****\$1,340.00**Processing fee of **\$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (f)).**\$0.00****TOTAL NATIONAL FEE =****\$1,340.00**Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) (check if applicable). ☒**\$40.00****TOTAL FEES ENCLOSED =****\$1,380.00**

Amount to be:	\$
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- a. ☒ A check in the amount of **\$1,380.00** to cover the above fees is enclosed.
- b. ☐ Please charge my Deposit Account No. _____ in the amount of _____ to cover the above fees. A duplicate copy of this sheet is enclosed.
- c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. **19-4375**. A duplicate copy of this sheet is enclosed.
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NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

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DESCRIPTION

INTERLEAVE ADDRESS GENERATION APPARATUS AND INTERLEAVE ADDRESS GENERATION METHOD

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Technical Field

The present invention relates to an interleave address generation apparatus and interleave address generation method, and more particularly, to an
10 interleave address generation apparatus and interleave address generation method ideally applicable to a communication terminal apparatus or base station apparatus.

15 Background Art

One of conventional interleave address generation apparatuses and interleave address generation methods is described in the Unexamined Japanese Patent Publication No.HEI 7-212250.

20 In accordance with the trend of the present times toward the worldwide standardization of a third-generation communication system, standardization plans on interleave are being proposed and GF interleave is one of the interleave methods currently being studied.

25 This GF interleave is one of block interleaves that perform processing on a two-dimensional array with the number of rows $N=2^r$ and the number of columns $M=2^c$. The GF interleave sequentially rearranges bits (hereinafter

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referred to as "column exchange") of a bit string of M bits in length delimited row by row from the first row to Nth row in different sequences, and generates an interleave address pattern by reading the matrix

5 subjected to the row exchange carried out according to the sequence based on a bit inversion method from the first row of the first column from top to bottom to the Nth row of the Mth column.

10 In the block-size matrix two-dimensional array above, an example of generating an interleave address pattern by calculating a row conversion pattern $\pi i(j)$ will be explained.

FIG.1 is a block diagram showing a configuration of a column exchange apparatus used for a conventional GF interleave.
15

In FIG.1, memory 11 outputs vector α^{i0} corresponding to row number i ($0 \leq i < N$) input to exclusive logical sum calculator 13. Memory 12 outputs vector α^j corresponding to column number j ($0 \leq j < M$) input to
20 exclusive logical sum calculator 13. Exclusive logical sum calculator 13 calculates an exclusive logical sum of α^{j0} and α^j and outputs calculation result β to memory 14.

Memory 14 outputs column conversion pattern $\pi i(j)$
25 for the i th row based on calculation result β . $\pi i(j)$ is calculated from following expression (1).

$$\pi_i(j) = \begin{cases} \log_{\alpha}(\alpha^{i_0} + \alpha^j) & \text{for } j=0,1,\dots,M-2 \\ \log_{\alpha}(\alpha^{i_0}) & \text{for } j=M-1 \end{cases} \quad (1)$$

Furthermore, conversions in memory 11, memory 12 and memory 14 are carried out using the conversion table shown in FIG.2.

FIG.2 shows a conversion table used for the GF
5 interleave.

The conversion table in FIG.2 is a table that shows correspondences between power in a Galois field power expression and a vector expression with the Galois field polynomial basis.

10 The vector expression consists of vectors output from memory 11 and memory 12 and vectors input to memory 14. Power $\log_{\alpha} \beta$ in a power expression is a value input to memory 11 or memory 12 and a value output from memory 14.

15 Here, the column conversion pattern on the i th row is obtained through the operation shown below. By calculating parameter i_0 corresponding to row number i in memory 11, vector α^{i_0} corresponding to parameter i_0 is output. Exclusive logical sum calculator 13
20 calculates an exclusive logical sum of α^{i_0} and α^j output from memory 11 and memory 12 and memory 14 outputs $\log_{\alpha} \beta$ corresponding to calculation result β .

By fixing address value i of memory 11 and incrementing address value j of memory 12 from 0, column
25 conversion pattern $\pi_i(j)$ corresponding to the i th row

is generated.

Then, an example of interleave address generation is shown below.

FIG.3A, FIG.3B, FIG.3C and FIG.3D illustrate the
5 process of generation of interleave addresses.

An example of creating an interleave address pattern of size 30 on an 8×4 two-dimensional array will be explained below.

First, the interleave address generation apparatus
10 stores an interleave address pattern with addresses 0 to 7 rearranged in the column direction in memory ($i=0$, $j=0$ to 7).

Likewise, the interleave address generation
15 apparatus stores an interleave address pattern with addresses 0 to 7 rearranged in different sequences from the next rows onward in memory ($i=1$ to 3, $j=0$ to 7). The storage result is shown in FIG.3A.

Then, the interleave address generation apparatus performs rearrangement processing in row units. More
20 specifically, row $i=1$ and row $i=2$ are switched round. The switching result is shown in FIG.3B.

Then, the interleave address generation apparatus adds an offset address to the stored value in row units. More specifically, a value obtained by multiplying the
25 value of i by the number of column components is added to the value of i . For example, value 16 obtained by multiplying 2, the value of i , by 8, the number of components, is added to values on the 2nd column

respectively. Value 8 obtained by multiplying 1, the value of i , by 8, the number of components, is added to values on the 3rd column respectively. Value 24 obtained by multiplying 3, the value of i , by 8, the number of components, is added to values on the 4th column respectively. The addition result is shown in FIG.3C.

Then, the interleave address generation apparatus extracts addresses in the column direction from memory and outputs only addresses smaller than the size of the interleave address pattern to be created. More specifically, in FIG.3C, value 7 stored in $i=0$, $j=0$ is output and then value 20 stored in $i=2$, $j=0$, value 14 stored in $i=1$, $j=0$ and value 29 stored in $i=3$, $j=0$ are output. Then, value 3 stored in $i=0$, $j=1$ is output and then value 22 stored in $i=2$, $j=1$, value 12 stored in $i=1$, $j=1$ and value 26 stored in $i=3$, $j=1$ are output. Likewise, the interleave address generation apparatus extracts values stored in memory in the column direction and outputs the extracted values as an interleave address pattern. FIG.3D shows the interleave address pattern output.

However, the conventional interleave address generation method develops an interleave address pattern created in predetermined units in memory and then performs row rearrangement and an addition of offset addresses, and thus the conventional interleave address generation method has a problem that a considerable memory space and considerable processing time are

required to generate an interleave address pattern.

Disclosure of Invention

It is an object of the present invention to provide
5 an interleave address generation apparatus and
interleave address generation method capable of
generating an interleave address pattern with a small
memory space and short processing time.

This object is attained by simultaneously carrying
10 out row rearrangement processing and column
rearrangement processing during generation of
interleave addresses and continuously carrying out this
row rearrangement processing and column rearrangement
processing and offset address addition processing to
15 create interleave addresses.

Brief Description of Drawings

FIG.1 is a block diagram showing a configuration
of a column exchange apparatus used in a conventional
20 GF interleave;

FIG.2 illustrates a conversion table used in the
GF interleave;

FIG.3A illustrates a process of generation of
interleave addresses;

25 FIG.3B illustrates a process of generation of
interleave addresses;

FIG.3C illustrates a process of generation of
interleave addresses;

FIG.3D illustrates a process of generation of interleave addresses;

FIG.4 is a block diagram showing a configuration of an interleave address generation apparatus according to Embodiment 1 of the present invention;

FIG.5 illustrates a data configuration example in an exclusive logical sum calculation in the embodiment above;

FIG.6 illustrates an example of generation of interleave addresses;

FIG.7 is a block diagram showing a configuration example of an interleave address generation apparatus according to Embodiment 2 of the present invention;

FIG.8 is a block diagram showing a configuration example of an interleave address generation apparatus according to Embodiment 3 of the present invention;

FIG.9 illustrates a table example stored in memory;

FIG.10 illustrates a table example stored in memory;

FIG.11A illustrates an example of row number i and column number j output from counter control section 201;

FIG.11B illustrates an example of the converted row number and column number;

FIG.11C illustrates an example of an addition result output from an adder;

FIG.11D illustrates an example of interleave address output from interleave address apparatus 200;

FIG.12 is a block diagram showing a configuration

of an interleave apparatus according to Embodiment 4 of the present invention;

FIG.13 is a block diagram showing a configuration of a turbo coding apparatus according to Embodiment 5 of the present invention;

FIG.14 is a block diagram showing a configuration of a turbo decoding apparatus according to Embodiment 6 of the present invention;

FIG.15 is a block diagram showing a configuration of a communication terminal apparatus according to Embodiment 7 of the present invention; and

FIG.16 is a block diagram showing a configuration of a base station apparatus according to Embodiment 8 of the present invention.

15

Best Mode for Carrying out the Invention

With reference now to the attached drawings, embodiments of the present invention will be explained below.

20

(Embodiment 1)

The interleave address generation apparatus according to Embodiment 1 carries out row rearrangement processing and column rearrangement processing in parallel.

25

FIG.4 is a block diagram showing a configuration of the interleave address generation apparatus according

to Embodiment 1 of the present invention.

Interleave address generation apparatus 100 shown in FIG.4 is mainly constructed of counter control section 101, bit inversion apparatus 102, column conversion apparatus 103, shift register 104, adder 105 and size comparison section 106.

Furthermore, column conversion apparatus 103 is mainly constructed of memory 110, memory 111, memory 113 and exclusive logical sum calculator 112.

10 In FIG.4, counter control section 101 outputs row number i ($0 \leq i < 2^2$) on a two-dimensional array to bit inversion apparatus 102 and column number j ($0 \leq j < 2^3$) on a two-dimensional array to memory 111.

For example, when addresses on a $2^2 \times 2^3$ two-dimensional array are output, counter control section 15 101 outputs row number $i=0$, column number $j=0$, then outputs row number $i=1$, column number $j=0$. Then, counter control section 101 outputs row number $i=2$, column number $j=0$, then outputs row number $i=3$, column number $j=0$.

20 Then, counter control section 101 outputs row number $i=0$, column number $j=1$. In this way, counter control section 101 increases the value of column number j every time the value of row number i exceeds a maximum value of 3, sets and outputs $i=0$ and continues to output 25 up to a combination of row number $i=3$ and column number $j=7$.

Bit inversion apparatus 102 carries out bit inversion of row number i output from counter control

section 101 in a binary state and outputs bit-inverted row number i' to memory 110 and shift register 104. More specifically, bit inversion apparatus 102 switches between the higher digit and the lower digit of the binary coded row number. That is, bit inversion apparatus 102 switches the highest digit and lowest digit, then switches between the 2nd highest digit and the 2nd lowest digit. And this same switching between a higher digit and lower digit is continued.

10 Memory 110 stores values resulting from assigning different i_0 's to α^{i_0} on respective rows, calculates i_0 corresponding to i' input and outputs α^{i_0} corresponding to i_0 to exclusive logical sum calculator 112.

15 Memory 111 stores values resulting from assigning different j 's to α^j ($0 \leq j < M$) on respective rows and outputs α^j corresponding to j input to exclusive logical sum calculator 112.

Exclusive logical sum calculator 112 calculates an exclusive logical sum of α^{i_0} output from memory 110 and α^j output from memory 111 and outputs the calculation result to memory 113.

25 Memory 113 stores the column conversion pattern corresponding to the calculation result of exclusive logical sum calculator 112 and outputs the column conversion pattern corresponding to the calculation result input to adder 105.

Shift register 104 bit-shifts the value output from bit inversion apparatus 102 and outputs this to adder

105 as an address offset value.

Adder 105 adds up the output from shift register 104 and the output from column conversion apparatus 103 and outputs the addition result to size comparison
5 section 106.

Size comparison section 106 compares the addition result output from adder 105 with the interleave size and outputs the addition result which is not greater than the interleave size as an address value.

10 Then, the data processing in the interleave address generation apparatus of this embodiment will be explained.

The following explanations will describe a case assuming that interleave size $L=30$, $N (=2^r) \times M (=2^c)$ block
15 size, $r=2$, $C=3$, primitive polynomial of degree 3 expressed in Galois field $GF(23)$ is x^3+x+1 and the root of the primitive polynomial is α . All the originals in Galois field $GF(23)$ can be expressed in power of α .

FIG.5 illustrates a data configuration example in
20 an exclusive logical sum calculation of this embodiment.

Memory 110 stores parameter i_0 corresponding to row number i in correspondence with 3-bit vector α^{i_0} and outputs 3-bit vector α^{i_0} corresponding to i_0 input.

Memory 111 stores parameter j corresponding to row
25 number i in correspondence with α^j and outputs 3-bit vector α^j corresponding to j input.

Exclusive logical sum calculator 112 carries out an exclusive logical sum of vector α^{i_0} and vector α^j and

outputs calculation result β to memory 113.

Memory 113 outputs the column-rearranged data corresponding to calculation result β .

Then, the data processing of the interleave address generation apparatus according to this embodiment will be explained.

FIG.6 shows an example of creation of interleave addresses.

In FIG.6, i and j denote a row number and column number output from counter control section 101 and i' denotes a row number output from bit inversion apparatus 102. Furthermore, α^{i0} and α^j denote vector data output from memory 110 and memory 111 and $\alpha^{i0} + \alpha^j$ denotes the calculation result in exclusive logical sum calculator 112. $\text{Log}_\alpha \alpha^{i0} + \alpha^j$ denotes data output from memory 113 and the offset addition result denotes the result of the addition of an offset address output from shift register 104.

Data processing is carried out on one row at a time starting from the top row.

First, counter control section 101 outputs row number $i=0$, column number $j=0$. Bit inversion apparatus 102 outputs row number i after switching between the higher digit and lower digit of the row number bits in a binary state. Row number $i=0$ is expressed as "00" in a two-bit binary number and when the higher bit and lower bit are switched round, the row number is "00" and row number $i'=0$ is output.

Memory 110 outputs α^{i_0} corresponding to row number i' . When row number $i'=0$ is input, $\alpha^{i_0} = (1,0,0)$ is output.

Memory 111 outputs α^j corresponding to row number
5 j. When row number j=0 is input, $\alpha^j = (1,0,0)$ is output.

Exclusive logical sum calculator 112 calculates an exclusive logical sum of α^{i_0} output from memory 110 and α^j output from memory 111. When $\alpha^{i_0} = (1, 0, 0)$ and $\alpha^j = (1, 0, 0)$, $\alpha^{i_0} + \alpha^j = (0, 0, 0)$ is output.

Memory 113 outputs column-rearranged data $\log_a(\alpha^{i_0} + \alpha^j)$ corresponding to calculation result $\alpha^{i_0} + \alpha^j$ output from exclusive logical sum calculator 112. When $\alpha^{i_0} + \alpha^j = (0, 0, 0)$, "4" is output as the column-rearranged data.

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15      Adder 105 adds a value obtained by multiplying the
      total number of column number j by i' to the column-
      rearranged data and outputs the addition result. When
      the column-rearranged data is 4, i'=0 and the number of
      column number j is 8, "7" is output as the interleave
20      address.

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After the interleave address with $i=1$, $j=0$ is output, counter control section 101 outputs row number $i=1$, column number $j=0$, and the same processing as the above is carried out and "20" is output as the interleave address.

This is followed by processing with i=2, j=0 and processing with i=3, j=0. When i=3, exceeding a maximum value, j is incremented and the value is reset to i=0

and then, processing with $i=0$, $j=1$ is carried out.

As shown above, the interleave address generation apparatus controls so that i is reset every time i exceeds a maximum value and in this way sequentially outputs
 5 addresses for a $2^2 \times 2^3$ two-dimensional array in the column direction. Furthermore, the interleave address generation apparatus uses output i' from bit inversion apparatus 102 as the read address value for memory 110, and can thereby carry out row exchange on the
 10 aforementioned two-dimensional array simultaneously.

Thus, the interleave address generation apparatus according to Embodiment 1 outputs row numbers and column numbers individually and converts numbers individually, and can thereby carry out row rearrangement processing
 15 and column rearrangement processing in parallel, allowing an interleave address pattern to be generated in a small space and short processing time.

The explanation above describes the case of interleave address generation when the size of an
 20 interleave address pattern is 30 and the block size is $2^2 \times 2^3$, but it is possible to carry out block interleave of $N(2^r) \times M(2^c)$ for an arbitrary number of data L by changing the memory data to be stored and setting the number of shifts of shift register 104 to c bits.

25

(Embodiment 2)

FIG.7 is a block diagram showing a configuration example of an interleave address generation apparatus

according to Embodiment 2. However, the configuration common to that in FIG.4 is assigned the same reference numerals as those in FIG.4 and detailed explanations thereof are omitted.

5 Interleave address generation apparatus 150 in FIG.7 is different from FIG.4 in that interleave address generation apparatus 150 is equipped with storage cell array 151 and adds up offset addresses according to the output timing from memory 113.

10 In FIG.7, storage cell array 151 temporarily stores row number i' output from bit inversion apparatus 102 and then outputs row number i' to shift register 104.

For example, storage cell array 151 is constructed of a two-stage storage cell array to adjust the timings of the output from column conversion apparatus 103 and the output from shift register 104 to the timing of the output value i' from bit inversion apparatus 102.

Then, output value i' from bit inversion apparatus 102 is temporarily stored in storage cell array 151, sequentially output in synchronization with the addition timing of adder 105, input to shift register 104 and a value resulting from shifting 3 bits is output as an address offset value for the i' th row.

Thus, the interleave address generation apparatus 25 according to Embodiment 2 outputs row numbers and column numbers individually and converts numbers individually, and can thereby carry out row rearrangement processing and column rearrangement processing in parallel,

allowing an interleave address pattern to be generated in a small space and short processing time.

Furthermore, the interleave address generation apparatus according to Embodiment 2 can adjust the output timing of the adder by delaying the output timing of an offset address value using a temporary storage circuit, making it possible to generate an interleave address pattern even when the speed of generation of an offset address value is different from that of a column exchange pattern.

(Embodiment 3)

FIG.8 is a block diagram showing a configuration example of an interleave address generation apparatus according to Embodiment 3.

In FIG.8, counter control section 201 outputs row number i of a two-dimensional array to memory 202 and outputs column number j of a two-dimensional array to memory 203.

Memory 202 stores $N(i)$ corresponding to input i and outputs $N(i)$ corresponding to i output from counter control section 201 to multiplier 204.

Memory 203 stores $M(j)$ corresponding to input j and outputs $M(j)$ corresponding to j output from counter control section 201 to adder 205.

Multiplier 204 multiplies $N(i)$ output from memory 202 by the number of columns M and outputs the multiplication result to adder 205.

5 When the addition result output from adder 205 is smaller than the size of the required interleave address, size comparison section 206 outputs the addition result as the interleave address and when the addition result is equal to or greater than the size of the required
10 interleave address, size comparison section 206 does not output the addition result.

FIG.9 shows a table example stored in memory 202.

15 In FIG.9, $N(i)$ is an output corresponding to input i and i has a one-to-one correspondence with $N(i)$ and $N(i)$ s corresponding to different i 's take mutually different values.

Then, the conversion operation of memory 203 will be explained.

In FIG.10, $M(j)$ is an output corresponding to input j and j has a one-to-one correspondence with $M(j)$ and

M(j)s corresponding to different j's take mutually different values.

When j=0 is input, memory 203 outputs M(j)= 3. When j=1 is input, memory 202 outputs M(j)=6. When j=2 is input, memory 202 outputs M(j)=4. When j=3 is input, memory 202 outputs M(j)=2. Likewise, when i=4 to 7, M(j) corresponding to j is output according to the table in FIG.10.

Then, an example of generation of interleave addresses will be shown.

FIG.11A illustrates an example of row number i and column number j output from counter control section 201.

When addresses of a $2^2 \times 2^3$ two-dimensional array is output, counter control section 201 outputs row number i=0, column number j=0 and then row number i=1, column number j=0. Then, counter control section 201 outputs row number i=2, column number j=0, and row number i=3, column number j=0.

Then, counter control section 201 outputs row number i=0, column number j=1. Thus, counter control section 201 increases the value of column number every time the value of row number i exceeds a maximum value of 3, sets and outputs i=0, and continues to output up to a combination of row number i=3 and column number j=7.

FIG.11B illustrates an example of converted row numbers and column numbers.

Row number i output from counter control section 201 is converted to N(i) according to the table in FIG.9

and column number j is converted to $M(j)$ according to the table in FIG.10.

For example, when counter control section 201 outputs row number $i=0$, column number $j=0$, memory 202 outputs $N(i)=2$ and memory 203 outputs $M(j)=3$.

FIG.11C illustrates an example showing the addition result output from adder 205.

Adder 205 outputs a value obtained by adding $M(j)$ to a multiplication result of multiplying $N(i)$ by the number of columns.

For example, when $N(i)=2$, $M(j)=3$, adder 205 outputs 19, a value obtained by adding $M(j)$ to a multiplication result of multiplying the number of columns 8 by $N(i)$.

Size comparison section 206 outputs addition results among other addition results in FIG.11C which are smaller than the requested interleave address size as the interleave addresses.

FIG.11D illustrates an example of interleave addresses output from interleave address apparatus 200.

For example, when the size of the requested interleave address is 30, addition results whose value is 29 or smaller are output as interleave addresses and addition results equal to or greater than 30 are not output.

Thus, the interleave address generation apparatus according to Embodiment 3 carries out row rearrangement processing and column rearrangement processing in parallel, and carries out this row rearrangement

processing and column rearrangement processing and offset address addition processing continuously, allowing an interleave address pattern to be generated in a small space and short processing time.

5 Furthermore, the interleave address generation apparatus according to Embodiment 3 can generate interleave addresses in a simpler configuration than Embodiment 1 or Embodiment 2 by using a same column exchange pattern on respective rows.

10

(Embodiment 4)

FIG.12 is a block diagram showing a configuration of an interleave apparatus according to Embodiment 4 of the present invention.

15

In FIG.12, interleave address generation apparatus 301 outputs an interleave address pattern to memory 303 according to an input instruction by which data is input to memory.

20

Address counter 302 outputs addresses one by one starting from the start address in memory to memory 303 according to a data output instruction by which data is output.

Memory 303 stores data sequentially at addresses output from interleave address generation apparatus 301, and after storing a predetermined amount of data, outputs address data output from address counter 302 sequentially.

25

Thus, the interleave apparatus of this embodiment

can perform high-speed interleave processing with small memory by rearranging information series using an interleave address pattern generated by the interleave address generation apparatus of Embodiment 1 or

5 Embodiment 2.

The interleave apparatus of Embodiment 4 stores data in memory of addresses output from interleave address generation apparatus 301 and reads data from memory of addresses output from address counter 302, but
10 the present invention is not limited to this and it is also possible to store data in memory of addresses output from address counter 302, read data from memory of addresses output from interleave address generation apparatus 301 and rearrange data.

15

(Embodiment 5)

FIG.13 is a block diagram showing a configuration of a turbo coding apparatus according to Embodiment 5 of the present invention.

20 In FIG.13, turbo coding apparatus 400 is mainly constructed of recursive convolutional coder 401, interleaver 402 and recursive convolutional coder 403.

Recursive convolutional coder 401 performs convolutional code coding on an information series input
25 and outputs the coded information series to the outside.

Interleaver 402 is constructed of the interleave apparatus of Embodiment 4, performs interleave processing on the information series input and outputs

the interleaved information series to recursive convolutional coder 403.

Recursive convolutional coder 403 carries out convolutional code coding on the information series
5 output from interleaver 402 and outputs the coded information series to the outside.

Then, the operation of turbo coding apparatus 400 will be explained.

The input information series is subjected to
10 convolutional coding by recursive convolutional coder 401 and the coded information series is output.

Furthermore, the input information series is subjected to data rearrangement by interleaver 402 and the rearranged information series is subjected to
15 convolutional coding by recursive convolutional coder 403 and the coded information series is output.

That is, regarding the information series to be coded, 3 bits are output as a code series corresponding to 1 information series bit: the output of the
20 information series itself; the output from recursive convolutional coder 401 that performs coding of convolutional codes using the information series as an input; and the output of recursive convolutional coder 403 that performs coding of convolutional codes using
25 data rearranged by interleaver 402 as an input which is the data written in memory before being input to recursive convolutional coder 403 using the information series as an input.

Through the operation above, in response to the input of the information series, turbo coding apparatus 400 outputs the information series input, the information series subjected to convolutional coding and the information series subjected to data rearrangement and convolutional coding.

Thus, the turbo coding apparatus of this embodiment can speed up processing by rearranging information series using the interleave apparatus of Embodiment 4, and can thereby improve the error correcting performance.

For example, in turbo coding apparatus 400 of Embodiment 5, it is possible to implement turbo coding apparatus 400 with improved error correcting performance for decoding of a code series on the receiving side by applying the interleave apparatus of Embodiment 4 according to the GF interleave system to interleaver 402.

Furthermore, the turbo coding apparatus of this embodiment can speedily generate interleave addresses with small memory and perform interleave by rearranging the information series using the interleave apparatus of Embodiment 4, and can thereby perform turbo coding with small memory.

[Embodiment 6]

FIG.14 is a block diagram showing a configuration of a turbo decoding apparatus according to Embodiment 6 of the present invention.

In FIG.14, turbo decoding apparatus 500 is mainly constructed of soft decision output decoder 501, interleaver 502, soft decision output decoder 503 and deinterleaver 504.

5 Soft decision output decoder 501 decodes the code series input and outputs the input decoded code series to interleaver 502.

10 Interleaver 502 rearranges the code series output from soft decision output decoder 501 and outputs to soft decision output decoder 503.

 Soft decision output decoder 503 decodes the code series output from interleaver 502 and outputs to deinterleaver 504.

15 Deinterleaver 504 rearranges the code series output from soft decision output decoder 503 and outputs the obtained code series to soft decision output decoder 501 and the outside.

 Then, the operation of turbo decoding apparatus 500 will be explained.

20 In the initial operation, the code series subjected to convolutional coding by the turbo coding apparatus, etc. of Embodiment 5 is decoded by soft decision output decoder 501 and the obtained soft decision output is output to interleaver 502.

25 The soft decision output from soft decision output decoder 501 is subjected to data series rearrangement by interleaver 502 and output to soft decision output decoder 503.

interleaver 502 and interleaver 504.

Furthermore, the turbo decoding apparatus of this embodiment can reduce memory required for processing by rearranging information series using the interleave apparatus of Embodiment 4, and can thereby perform turbo coding with small memory.

(Embodiment 7)

FIG.15 is a block diagram showing a configuration of a communication terminal apparatus according to Embodiment 7 of the present invention.

In FIG.15, communication terminal apparatus 600 is mainly constructed of antenna 601, reception section 602, transmission section 603, demodulation section 604, modulation section 605, decoding processing section 606, coding processing section 607, speech CODEC section 608, data input/output section 609, speaker 610 and microphone 611.

Decoding processing section 606 is constructed of deinterleave section 614, rate matching section 615 and error correcting/decoding section 616.

Coding processing section 607 is constructed of error correcting/coding section 617, rate matching section 618 and interleave section 619.

Here, error correcting/coding section 617 is constructed using the interleave apparatus of Embodiment 4 or turbo coding apparatus 400 of Embodiment 5.

On the other hand, error correcting/decoding

section 616 is constructed using the interleave apparatus of Embodiment 4 or turbo decoding apparatus 500 of Embodiment 6 for non-speech data.

On the other hand, deinterleave section 614 and
5 interleave section 619 are constructed using the
interleave apparatus of Embodiment 4.

Antenna 601 transmits and receives signals.

Reception section 602 carries out radio processing
on the reception signal from antenna 601 and outputs the
10 reception signal subjected to radio processing to
demodulation section 604.

Transmission section 603 carries out radio processing on a transmission signal output from modulation section 605 and transmits to antenna 601.

15 Demodulation section 604 demodulates the reception
signal output from reception section 602 using
despreading apparatus 612 and outputs the demodulated
signal to deinterleave section 614.

Modulation section 605 modulates the transmission
20 signal output from interleave section 619 using
spreading apparatus 613 and outputs the modulated
transmission signal to transmission section 603.

Deinterleave section 614 carries out data rearrangement processing on the demodulated signal output from demodulation section 604 and outputs the rearranged data to rate matching section 615.

Rate matching section 615 adjusts the length of the data output from deinterleave section 614 to a length

that allows error correcting processing and outputs the data of the adjusted length to error correcting/decoding section 616.

5 Error correcting/decoding section 616 corrects errors of the data output from rate matching section 615 and outputs the error-corrected data to speech CODEC section 608.

10 Error correcting/coding section 617 carries out error correcting/coding on the transmission data output from speech CODEC section 608 and outputs to rate matching section 618.

15 Rate matching section 618 adjusts the transmission data output from error correcting/coding section 617 to a length required for interleave processing and outputs to interleave section 619.

Interleave section 619 applies rearrangement processing to the transmission data output from rate matching section 618 and outputs to modulation section 605.

20 Speech CODEC section 608 carries out coding on a speech signal output from microphone 611 and outputs to error correcting/coding section 617 as transmission data.

25 Furthermore, speech CODEC section 608 decodes the reception data output from error correcting/decoding section 616 and outputs the decoded speech data to speaker 610.

Microphone 611 outputs an input speech to speech

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CODEC section 608 as speech data.

Speaker 610 outputs the speech data output from speech CODEC section 608 as speech.

Then, the operation of communication terminal
5 apparatus 600 during transmission will be explained.

When speech is transmitted, the speech is analog-to digital-converted (hereinafter referred to as "AD conversion") to a speech signal by microphone 611, output to speech CODEC section 608, coded by speech CODEC
10 section 608, subjected to convolutional coding by error correcting/coding section 617 and output to rate matching section 618 as transmission data.

Furthermore, when non-speech data is transmitted, the non-speech data is sent through data input/output
15 section 609 to error correcting/coding section 617 where the non-speech data is subjected to turbo coding and convolutional coding according to the data transfer rate and output to rate matching section 618 as transmission data.

20 The transmission data is adjusted to a length required for interleave processing by rate matching section 618, rearranged by interleave section 619, digital-modulated and digital-to-analog-converted (hereinafter referred to as "DA conversion") by
25 modulation section 605, subjected to radio processing by transmission section 603 and transmitted via antenna 601.

Then, the operation of communication terminal

apparatus 600 during reception will be explained.

A reception signal is received via antenna 601, subjected to radio processing and AD conversion by reception section 602, digital-demodulated by
5 demodulation section 604 and output to deinterleave section 614 as reception data.

The reception data is subjected to rearrangement processing by deinterleave section 614, adjusted to a data length appropriate for error correction by rate
10 matching section 615 and output to error correcting/decoding section 616.

In the case where the reception data is a speech signal, the reception data is subjected to Viterbi decoding by error correcting/decoding section 616,
15 subjected to speech decoding and DA conversion by speech CODEC section 608 and output from speaker 610 as speech.

In the case where the reception data is a non-speech signal, the reception data is subjected to turbo decoding by error correcting/decoding section 616 according to
20 the data transfer rate and output to the outside via data input/output section 609.

Thus, the communication terminal apparatus of this embodiment can transmit/receive non-speech communications with a communication characteristic of
25 high transmission quality at a lower bit-to-error rate by applying the interleave apparatus of Embodiment 4 to the error correcting/coding apparatus and error correcting/decoding apparatus for non-speech data.

Furthermore, the interleaver included in turbo coding/decoding is constructed of an interleave apparatus that allows high-speed processing and with a reduced amount of memory, and therefore can implement communication terminal apparatus 600 allowing high-speed interleave processing with a reduced amount of memory.

This embodiment describes the case where the communication terminal apparatus is applied to a CDMA communication, but the communication system is not limited to this, and the present invention can also be applied to other communication systems by replacing spreading apparatus 613 in modulation section 605 and despreading apparatus 612 in demodulation section 604 with a modulation apparatus and demodulation apparatus according to the relevant communication system.

(Embodiment 8)

FIG.16 is a block diagram showing a configuration of a base station apparatus according to Embodiment 8 of the present invention.

Base station apparatus 700 shown in FIG.16 is mainly constructed of antenna 701, reception section 702, transmission section 703, demodulation section 704, modulation section 705, decoding processing section 706, coding processing section 707 and data input/output section 708.

Decoding processing section 706 is constructed of

deinterleave section 709, rate matching section 710 and error correcting/decoding section 711.

Coding processing section 707 is constructed of error correcting/coding section 712, rate matching
5 section 713 and interleave section 714.

Error correcting/coding section 712 is constructed using interleave address generation apparatus 100 or 200 of Embodiment 1 or turbo coding apparatus 400 of Embodiment 4.

10 Error correcting/decoding section 711 is constructed using the interleave apparatus of Embodiment 4 or turbo decoding apparatus 500 of Embodiment 5 for non-speech data.

Deinterleave section 709 and interleave section
15 714 are constructed using the interleave apparatus of Embodiment 4.

Antenna 701 transmits/receives signals.

Reception section 702 carries out radio processing on the reception signal from antenna 701 and outputs the
20 reception signal to demodulation section 704.

Transmission section 703 carries out radio processing on a transmission signal output from modulation section 705 and transmits to antenna 701.

Demodulation section 704 demodulates the reception
25 signal output from reception section 702 using despreading apparatus 715 and outputs the demodulated signal to deinterleave section 709.

Modulation section 705 modulates the transmission

signal output from interleave section 714 using spreading apparatus 716 and outputs the modulated transmission signal to transmission section 703.

Deinterleave section 709 carries out data rearrangement processing on the demodulated signal output from demodulation section 704 and outputs the rearranged data to rate matching section 710.

Rate matching section 710 adjusts the length of the data output from deinterleave section 709 to a length that allows error correcting processing and outputs the data of the adjusted length to error correcting/decoding section 711.

Error correcting/decoding section 711 carries out decoding and error correction on the data output from rate matching section 710 and outputs the error-corrected data to data input/output section 708.

Error correcting/coding section 712 carries out error correcting/coding on the transmission data output from data input/output section 708 and outputs to rate matching section 713.

Rate matching section 713 adjusts the transmission data output from error correcting/coding section 712 to a length required for interleave processing and outputs to interleave section 714.

Interleave section 714 applies rearrangement processing to the transmission data output from rate matching section 713 and outputs to modulation section 705.

Data input/output section 708 outputs the data to be transmitted to error correcting/coding section 712 and outputs the reception data output from error correcting/decoding section 711 to the outside.

5 Then, the operation of base station apparatus 700 during transmission will be explained.

10 The transmission data is sent through data input/output section 708 to error correcting/coding section 712 where the transmission data is subjected to turbo coding and convolutional coding according to the transfer rate or type of data and output to rate matching section 713 as transmission data.

15 The transmission data is adjusted to a length required for interleave processing by rate matching section 713, rearranged by interleave section 714, digital-modulated and D/A-converted by modulation section 705, subjected to radio processing by transmission section 703 and transmitted via antenna 701.

20 Then, the operation of base station apparatus 700 during reception will be explained.

25 A reception signal is received via antenna 701, subjected to radio processing and AD conversion by reception section 702, digital-demodulated by demodulation section 704 and output to deinterleave section 709 as reception data.

The reception data is subjected to rearrangement processing by deinterleave section 709, adjusted to a

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data length appropriate for error correction by rate matching section 710 and output to error correcting/decoding section 711.

5 The reception data is subjected to turbo decoding by error correcting/decoding section 711 according to the data transfer rate and output to the outside via data input/output section 708.

10 Thus, the base station apparatus of this embodiment can transmit/receive with a communication characteristic of high transmission quality at a lower bit-to-error rate by applying the interleave address generation apparatus of Embodiment 1 to the error correcting/coding apparatus and error correcting/decoding apparatus.

15 For example, according to base station apparatus 700 of Embodiment 8, it is possible to obtain base station apparatus 700 with a communication characteristic with lower BER and of high transmission quality for non-speech communications by applying turbo coding apparatus 400
20 of Embodiment 5 to error correcting/coding section 712 and turbo decoding apparatus 500 of Embodiment 6 to error correcting/decoding section 711.

25 Furthermore, the configuration of the interleaver included in turbo coding and decoding allows high-speed processing and by configuring the apparatus using an interleave apparatus with a reduced amount of memory, it is possible to obtain base station apparatus 700 allowing high-speed interleave with a reduced amount of

memory.

By the way, this embodiment describes the case where the base station apparatus is applied to a CDMA communication, but the communication system is not limited to this, and the present invention can also be applied to other communication systems by replacing spreading apparatus 716 in modulation section 705 and despreading apparatus 715 in demodulation section 704 with a modulation apparatus and demodulation apparatus according to the respective communication systems.

As is apparent from the explanations above, the present invention can generate interleave address patterns with a smaller memory space and shorter processing time.

This application is based on the Japanese Patent Application No.HEI 11-286981 filed on October 7, 1999, entire content of which is expressly incorporated by reference herein.

20

What is claimed is:

1. An interleave address generation apparatus comprising:

5 interleave address generating means for generating an interleave address pattern of a predetermined size and sequentially outputting interleave addresses;

 offset address generating means for generating offset addresses; and

10 adding means for adding said offset addresses to said interleave addresses and outputting as interleave addresses.

2. The interleave address generation apparatus according to claim 1, wherein the interleave address generating means comprising:

 first variable converting means for converting a first variable using a predetermined first random pattern; and

20 second variable converting means for converting a second variable using a predetermined second random pattern, and

 the offset address generating means uses a value obtained by multiplying said converted first variable
25 by a maximum value of said second variable as an offset address.

3. The interleave address generation apparatus according

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to claim 1, wherein the interleave address generating means comprising:

first variable converting means for converting a first variable using a predetermined random pattern; and

5 second variable converting means for converting a second variable based on said converted first variable, and

the offset address generating means uses a value obtained by multiplying said converted first variable by a maximum value of said second variable as an offset address.

4. The interleave address generation apparatus according to claim 3, wherein the interleave address generating means calculates an exclusive logical sum of a vector expression with a polynomial basis of a Galois field using the first variable converted by the first variable converting means as power in a power expression of the Galois field and a vector expression with a polynomial basis of the Galois field using the second variable converted by the second variable converting means as power in a power expression of the Galois field, and uses a result of converting the vector obtained to power in a power expression of the Galois field using a vector expression with a polynomial basis of the Galois field, as a converted second variable.

5. The interleave address generation apparatus according

to claim 1, wherein the offset address generating means outputs an offset address in accordance with the timing at which the interleave address generating means outputs an interleave address.

5

6. An interleave apparatus that comprises an interleave address generation apparatus and storing means for storing data, stores data in said data storing means in the sequence of addresses output from said interleave address generation apparatus and extracts data from said data storing means sequentially starting from the start address after a predetermined unit of data is stored, wherein said interleave address generation apparatus comprising:

15 interleave address generating means for generating an interleave address pattern of a predetermined size and sequentially outputting interleave addresses;

 offset address generating means for generating offset addresses; and

20 adding means for adding said offset addresses to said interleave addresses and outputting as interleave addresses.

7. An interleave apparatus that comprises an interleave address generation apparatus and storing means for storing data, stores data in said data storing means sequentially starting from the start address and extracts data from said data storing means in the

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sequence of addresses output from said interleave address generation apparatus after a predetermined unit of data is stored, wherein said interleave address generation apparatus comprising:

5 interleave address generating means for generating an interleave address pattern of a predetermined size and sequentially outputting interleave addresses;

 offset address generating means for generating offset addresses; and

10 adding means for adding said offset addresses to said interleave addresses and outputting as interleave addresses.

8. A turbo coding apparatus comprising:

15 recursive convolutional coding means for carrying out convolutional coding of an information series; and

 an interleave apparatus for carrying out interleave processing of said information series, wherein said interleave apparatus comprises interleave address generating means for generating an interleave address pattern of a predetermined size and sequentially outputting interleave addresses, offset address generating means for generating offset addresses, adding means for adding said offset addresses to said interleave addresses and outputting as interleave addresses and
25 storing means for storing data, and extracts data from said data storing means sequentially starting from the start address after a predetermined unit of data is

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stored.

9. A turbo decoding apparatus comprising:

soft decision output decoding means for decoding
5 a code series;

a first interleave apparatus that carries out
interleave processing on the output of this soft decision
output decoding means;

soft decision output decoding means for decoding
10 the code series whose input data sequence is rearranged
by said first interleave apparatus; and

a second interleave apparatus that carries out
deinterleave processing on the output of this soft
decision output decoding means, wherein said first
15 interleave apparatus and said second interleave
apparatus comprise interleave address generating means
for generating an interleave address pattern of a
predetermined size and sequentially outputting
interleave addresses, offset address generating means
20 for generating offset addresses, adding means for adding
said offset addresses to said interleave addresses and
outputting as interleave addresses and storing means for
storing data, store data in said data storing means in
the sequence of interleave addresses output from said
25 adding means and extract data from said data storing
means sequentially starting from the start address after
a predetermined unit of data is stored.

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10. A communication terminal apparatus comprising an
interleave apparatus and radio communication means for
transmitting a signal output from said interleave
apparatus or outputting the received signal to said
5 interleave apparatus, wherein said interleave apparatus
comprises interleave address generating means for
generating an interleave address pattern of a
predetermined size and sequentially outputting
interleave addresses, offset address generating means
10 for generating offset addresses, adding means for adding
said offset addresses to said interleave addresses and
outputting as interleave addresses and storing means for
storing data, and stores data in said data storing means
in the sequence of interleave addresses output from said
15 adding means, and extracts data from said data storing
means sequentially starting from the start address after
a predetermined unit of data is stored.

11. A base station apparatus comprising an interleave
20 apparatus and radio communication means for transmitting
a signal output from said interleave apparatus or
outputting the received signal to said interleave
apparatus, wherein said interleave apparatus comprises
interleave address generating means for generating an
25 interleave address pattern of a predetermined size and
sequentially outputting interleave addresses, offset
address generating means for generating offset addresses,
adding means for adding said offset addresses to said

interleave addresses and outputting as interleave addresses and storing means for storing data, and stores data in said data storing means in the sequence of interleave addresses output from said adding means, and
 5 extracts data from said data storing means sequentially starting from the start address after a predetermined unit of data is stored.

12. An interleave address generation method comprising
 10 the steps of:

converting a first variable using a predetermined random pattern;

converting a second variable using a predetermined random pattern; and

15 adding a result of multiplying said first variable by a maximum value of said second variable to said second variable.

13. An interleave address generation method comprising
 20 the steps of:

rearranging a first variable using a predetermined random pattern;

rearranging a second variable based on said rearranged first variable;

25 calculating an exclusive logical sum of a vector expression with a polynomial basis of a Galois field using said converted first variable as power in a power expression of the Galois field and a vector expression

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with a polynomial basis of the Galois field using said converted second variable as power in a power expression of the Galois field;

converting the vector obtained to power in a power
5 expression of the Galois field using a polynomial basis of the Galois field; and

adding a result of multiplying the conversion result by a maximum value of said first variable and said second variable to the conversion result.

10

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ABSTRACT

Counter control section 101 increments a row number and column number on a two-dimensional array for a block
5 interleave expressed by a matrix two-dimensional array, outputs the incremented numbers as the read address values, bit inversion apparatus 102 performs bit inversion using the read address values as inputs, column conversion apparatus 103 outputs the address values
10 corresponding to the bit inversion output values and the column numbers from counter control section 101 as the column conversion values, shift register 104 bit-shifts the output values of bit inversion apparatus 102 and outputs as the address offset values, adder 106 adds up
15 the address offset values and column conversion values and size comparison section 106 compares the addition value with the interleave size and outputs data which is not greater than the interleave size as address values.

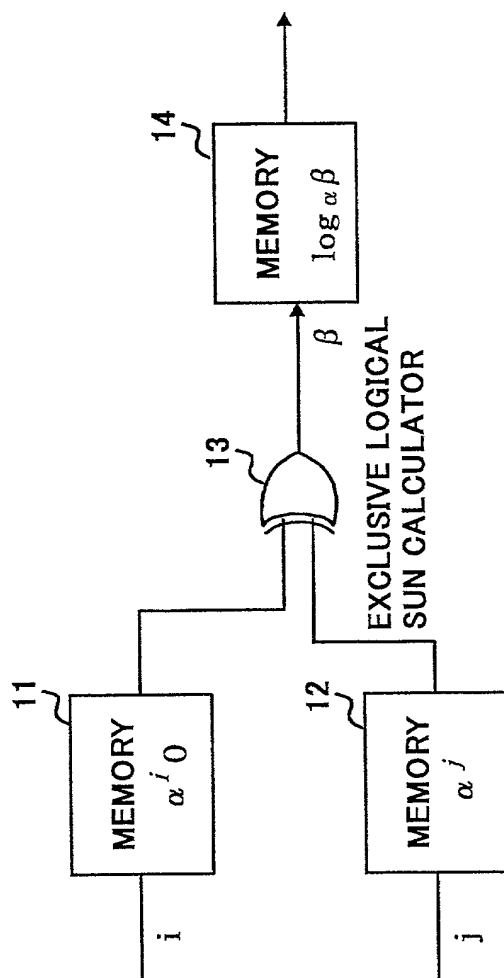


FIG.1

POWER EXPRESSION β	VECTOR EXPRESSION	$\log_{\alpha} \beta$
α^0	100	0
α^1	010	1
α^2	001	2
α^3	110	3
α^4	011	4
α^5	111	5
α^6	101	6
$\alpha^7(0)$	000	(7)

FIG.2

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$i \backslash j$	0	1	2	3	4	5	6	7	i_0
0	7	3	6	1	5	4	2	0	0
1	6	4	7	5	1	3	0	2	2
2	4	6	3	2	0	7	1	5	5
3	5	2	1	6	7	0	3	4	4

FIG.3A

$i \backslash j$	0	1	2	3	4	5	6	7	i_0
0	7	3	6	1	5	4	2	0	0
2	4	6	3	2	0	7	1	5	5
1	6	4	7	5	1	3	0	2	2
3	5	2	1	6	7	0	3	4	4

FIG.3B

$i \backslash j$	0	1	2	3	4	5	6	7	i_0
0	7	3	6	1	5	4	2	0	0
2	20	22	19	18	16	23	17	21	5
1	14	12	15	13	9	11	8	10	2
3	29	26	25	30	31	24	27	28	4

FIG.3C

[7, 20, 14, 29, 3, 22, 12, 26, 6, 19, 15, 25, 1, 18, 13, 5, 16, 9, 4, 23, 11, 24, 2, 17, 8, 27, 0, 21, 10, 28]

FIG.3D

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100:INTERLEAVE ADDRESS GENERATION APPARATUS

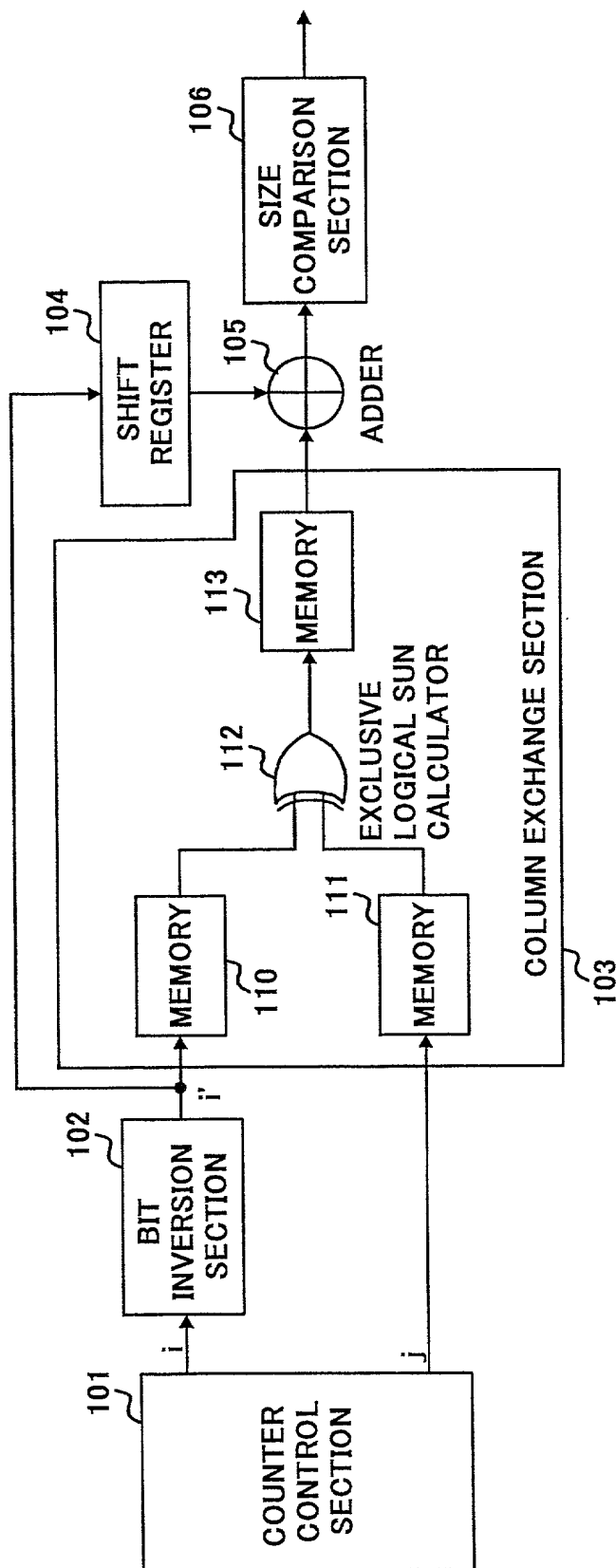


FIG.4

MEMORY 110

INPUT i 1 DECIMAL	io	OUTPUT α^{io}
0 0 (0)	0	(1, 0, 0)
1 0 (2)	2	(0, 0, 0)
0 1 (1)	5	(1, 1, 1)
1 1 (3)	4	(0, 1, 1)

MEMORY 113

INPUT	OUTPUT
(0, 0, 0)	7
(0, 0, 1)	0
(0, 1, 0)	1
(0, 1, 1)	3
(1, 0, 0)	2
(1, 0, 1)	6
(1, 1, 0)	4
(1, 1, 1)	5

MEMORY 111

INPUT i	OUTPUT α^i
0 0 0 (0)	(1, 0, 0)
0 0 1 (1)	(0, 1, 0)
0 1 0 (1)	(0, 0, 1)
0 1 1 (3)	(1, 1, 0)
1 0 0 (4)	(0, 1, 1)
1 0 1 (5)	(1, 1, 1)
1 1 0 (6)	(1, 0, 1)
1 1 1 (7)	(0, 0, 0)

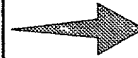


FIG.5

i	i''	j	α^{i0}	α^j	$\alpha^{i0} + \alpha^j$	$\log \alpha (\alpha^{i0} + \alpha^j)$	AFTER OFFSET ADDITION
0	0	0	(1, 0, 0)	(1, 0, 0)	(0, 0, 0)	7	$7+8 \times 0=7$
1	2	0	(1, 1, 1)	(1, 0, 0)	(0, 1, 1)	4	$4+8 \times 2=20$
2	1	0	(0, 0, 1)	(1, 0, 0)	(1, 0, 1)	6	$6+8 \times 1=14$
3	3	0	(0, 1, 1)	(1, 0, 0)	(1, 1, 1)	5	$5+8 \times 3=29$
0	0	1	(1, 0, 0)	(0, 1, 0)	(1, 1, 0)	3	$3+8 \times 0=3$
1	2	1	(1, 1, 1)	(0, 1, 0)	(1, 0, 1)	6	$6+8 \times 2=22$
2	1	1	(0, 0, 1)	(0, 1, 0)	(0, 1, 1)	4	$4+8 \times 1=12$
3	3	1	(0, 1, 1)	(0, 1, 0)	(0, 0, 1)	2	$2+8 \times 3=24$

FIG.6

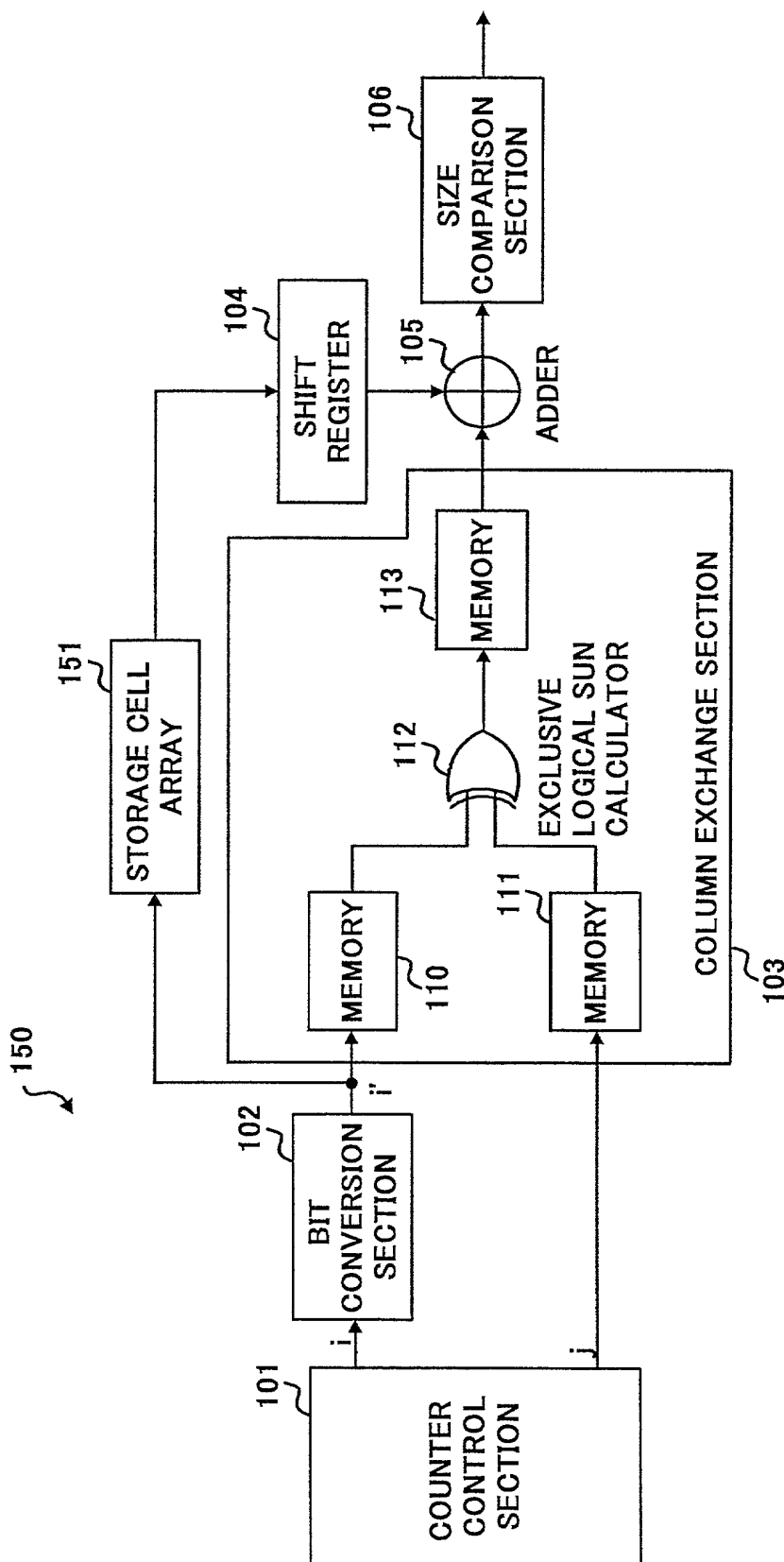


FIG.7

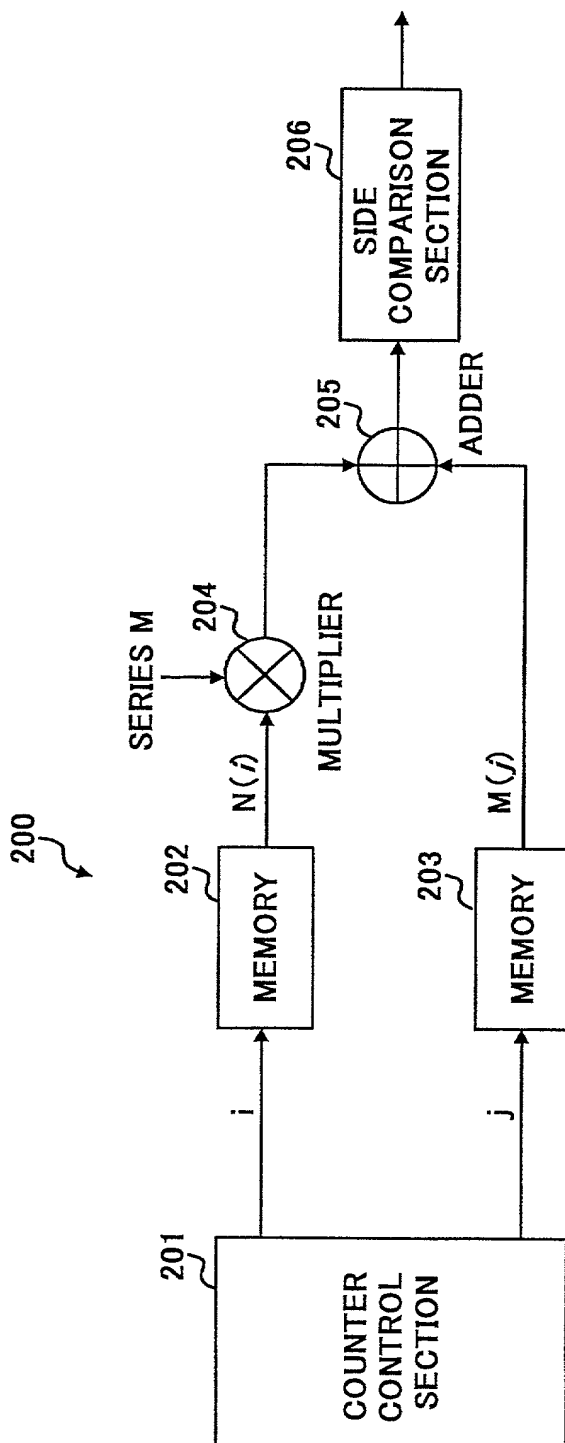


FIG.8

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i	$N(i)$
0	2
1	3
2	0
3	1

FIG.9

j	$M(j)$
0	3
1	6
2	4
3	2
4	1
5	5
6	7
7	0

FIG.10

<i>i</i>	0 1 2 3 0 1 2 3 0 0 1 2 3
<i>j</i>	0 0 0 0 1 1 1 1 2 7 7 7 7

FIG.11A

$N(i)$	2 3 0 1 2 3 0 1 2 2 3 0 1
$M(j)$	3 3 3 3 6 6 6 6 4 0 0 0 0

FIG.11B

ADDITION RESULT	19 27 3 11 22 30 6 14 20 23 31 7 15
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FIG.11C

INTERLEAVE ADDRESS	19 27 3 11 22 6 14 20 28 8 23 7 15
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FIG.11D

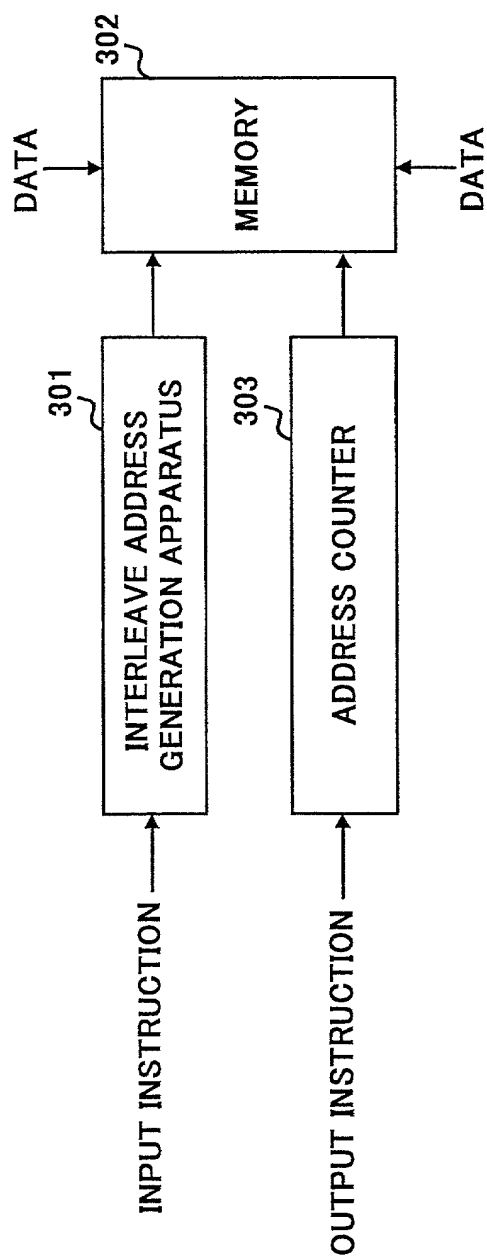


FIG.12

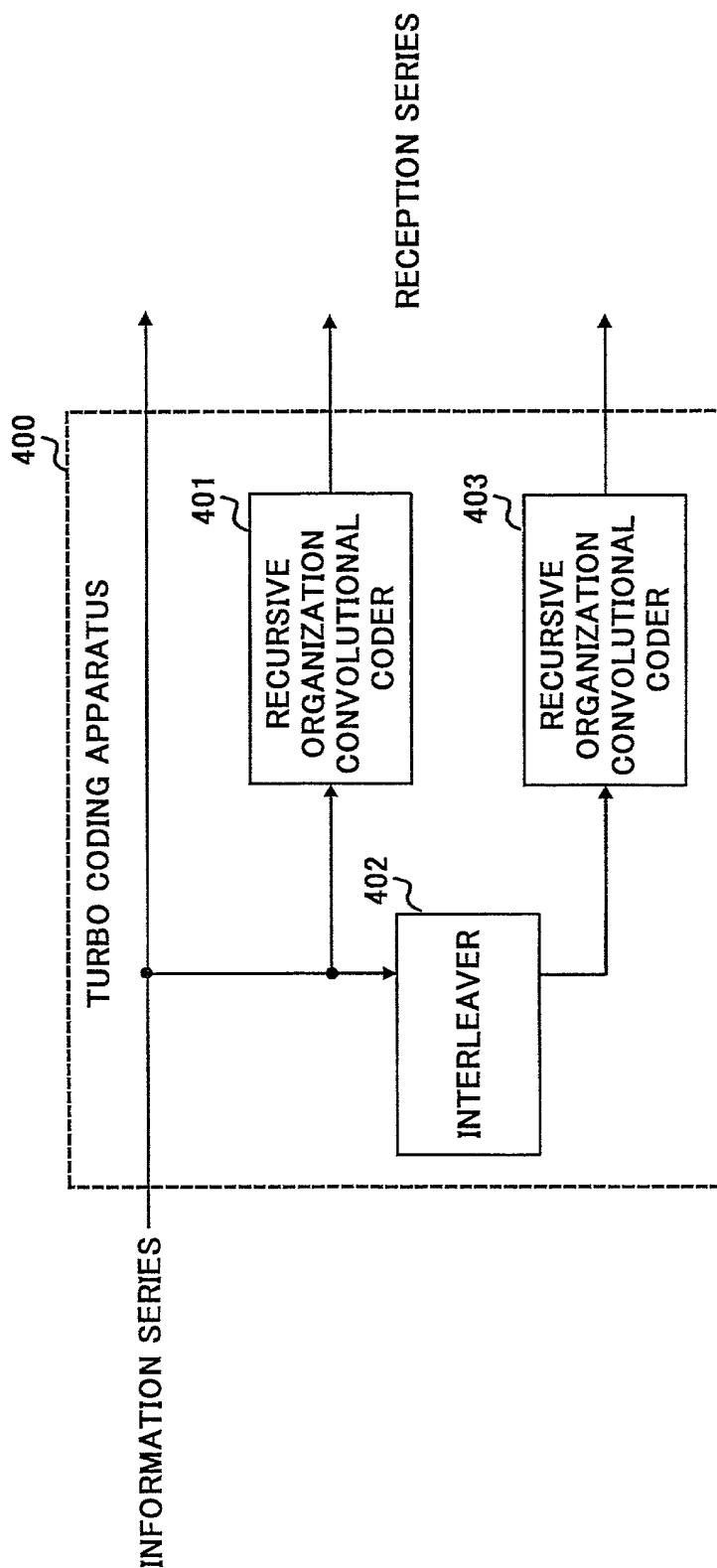


FIG.13

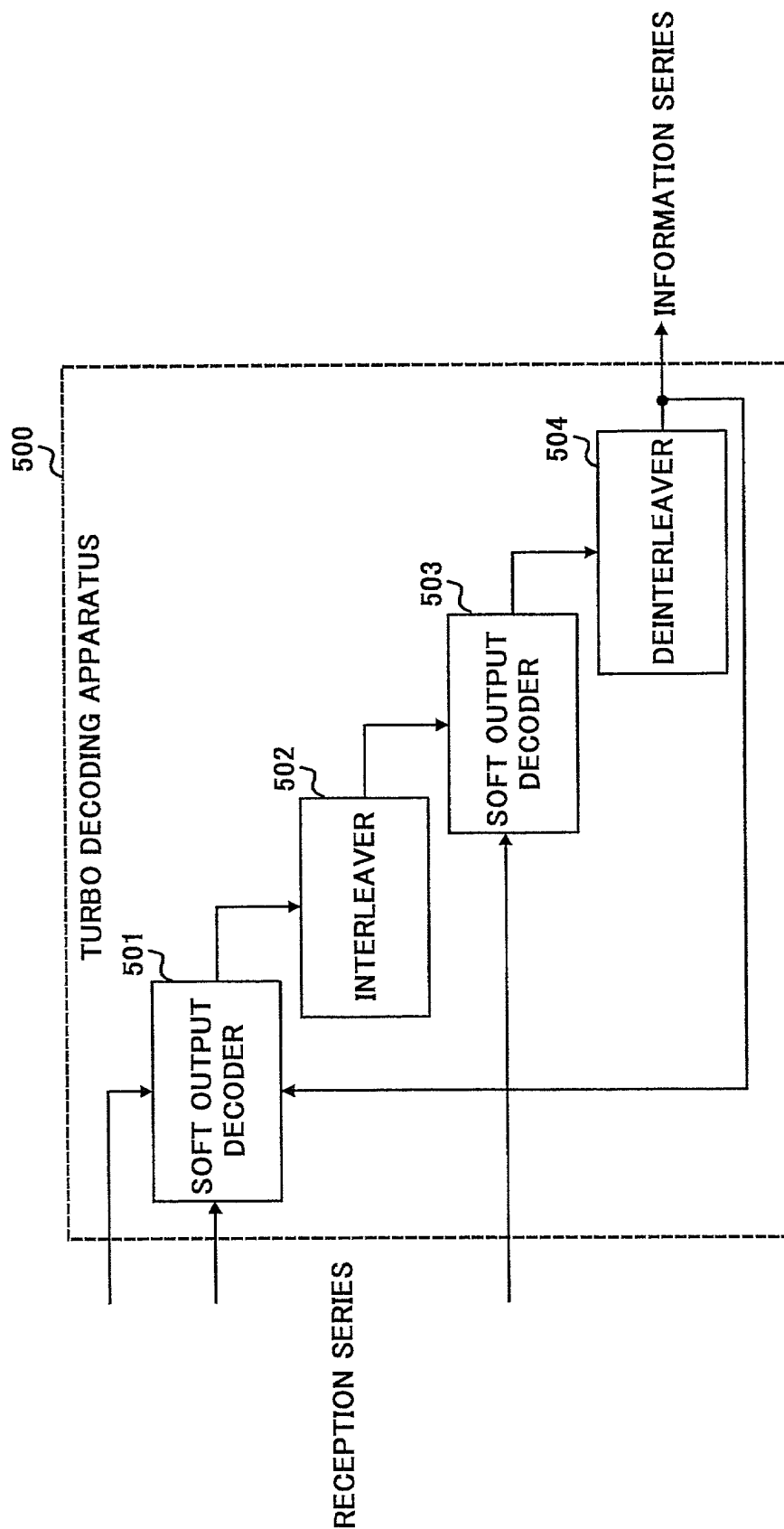


FIG.14

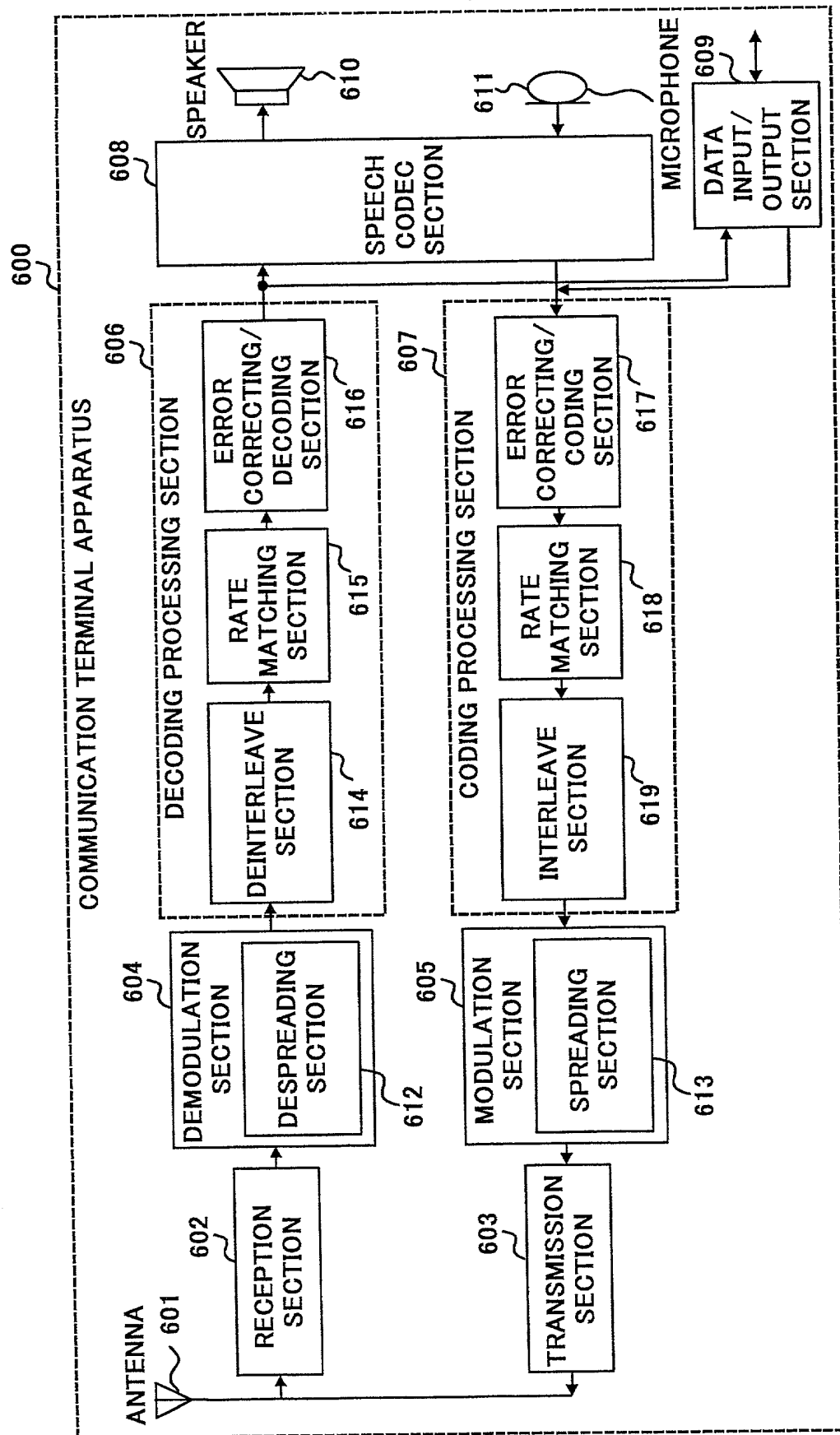


FIG.15

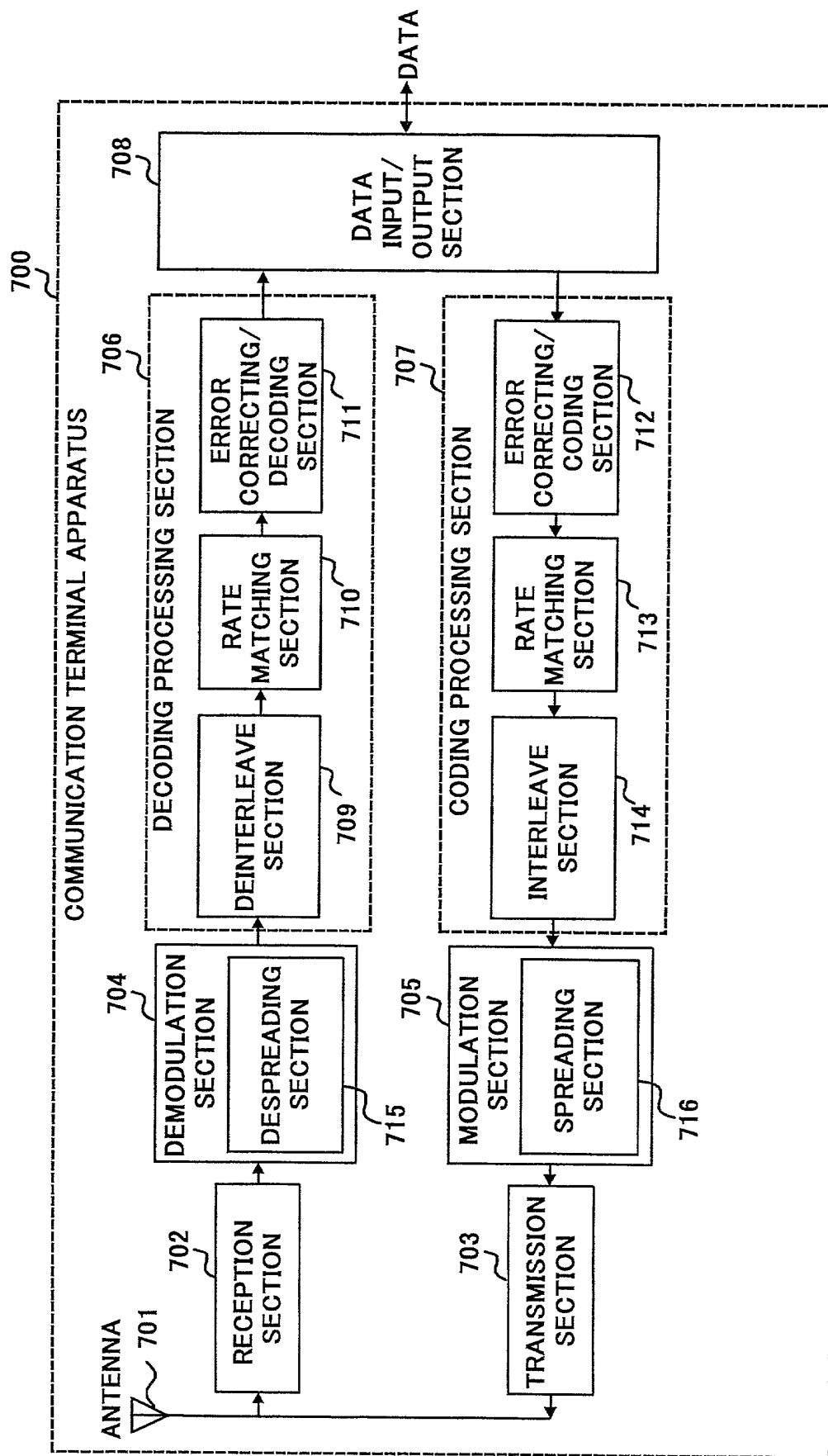


FIG.16

APPLICATION FOR UNITED STATES PATENT
Declaration for Patent Application

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on

the invention entitled: INTERLEAVE ADDRESS GENERATION APPARATUS AND INTERLEAVE ADDRESS GENERATION METHOD

the specification of which

2 (file no _____)

(check at least one)

3 ☒ is attached hereto

4 ☐ was filed on _____ as (5) U.S. Application Serial No. _____

6 ☐ and was amended _____
(if applicable)

Use this portion only if you are entering the U.S. National phase based on a PCT International Application designating the U.S. 7 ☐ was filed as PCT international application

8 Number PCT/IP00/06974

9 on October 06, 2000

and was amended under PCT Article(s) 19 and/or 34

10 on _____ (if applicable).

I hereby declare that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended, by any amendment referred to above.

I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me which is material to patentability in accordance with Title 37, Code of Federal Regulations, §1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application (s) for patent or inventor's certificate listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date earlier than that of the application(s) on which priority is claimed.

Prior (Foreign) Application(s) any Priority Claims Under 35 U.S.C. 119

Priority Claimed

1a Japan H11-286981 07/October/1999 ☒ ☐
(Country) (Number) (Day/Month/Year Filed) Yes No

_____ _____ _____ ☐ ☐
(Country) (Number) (Day/Month/Year Filed) Yes No

☐ Additional foreign application numbers are listed on a supplemental priority data sheet attached hereto.

Priority Claim(s) from U.S. Provisional Application(s) – I hereby claim the benefit under Title 35, United States Code, §119(e) of any United States provisional application(s) listed below:

11b _____
Application No. Day/Month/Year Filed Application No. Day/Month/Year Filed

Do not use this portion to identify a PCT application if the parent application is the U.S. National phase of the PCT application

I hereby claim the benefit under Title 35, United States Code, 120 of any United States application(s) or PCT international application(s) designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code §112, I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, §1.56 which became available between filing date of the prior application and the national or PCT international filing date of this application.

13 _____
(U.S. Application Number) (U.S. Filing Date) Status (patented, pending, abandoned)

I hereby appoint the following attorneys of the firm of Stevens, Davis, Miller & Mosher, L.L.P. as my attorneys of record with full power of substitution and revocation to prosecute this application and to transact all business in the Patent and Trademark Office:

James E. Ledbetter, Reg. No. 28732; Thomas P. Pavelko, Reg. No. 31689; and Anthony P. Venturino, Reg. No. 31674.

**ALL CORRESPONDENCE IN CONNECTION WITH THIS APPLICATION SHOULD BE SENT TO
STEVENS, DAVIS, MILLER & MOSHER, L.L.P., 1615 L Street, N.W., Suite 850, Washington, D.C. 20036,
TELEPHONE (202) 408-5100, FACSIMILE (202) 408-5200.**

See page 2 for signature lines

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful statements may jeopardize the validity of the application or any patent issuing thereon.

PAGE 2 OF U.S.A. DECLARATION FORM

13a	Typewritten Full Name of Sole or First Inventor	1-00 <u>Tetsuya</u> Given Name			<u>IKEDA</u> Middle Name		<u>IKEDA</u> Family Name	
14a	Inventor's Signature	<u>Tetsuya</u>			<u>Ikeda</u>			
15a	Date of Signature	<u>May</u> Month			<u>25</u> Day		<u>2001</u> Year	
16a	Residence	<u>Yokohama-shi</u> City			<u>Kanagawa</u> State or Province		<u>JAPAN</u> Country	
17a	Citizenship	<u>JAPAN</u>						
18a	Post Office Address (Insert complete mailing address, including country)	<u>31-26, Fujimigaoka, Tsuzuki-ku,</u> <u>Yokohama-shi, Kanagawa 224-0051 JAPAN</u>						
13b	Typewritten Full Name of Sole or Second Inventor	2-00 <u>Ryutaro</u> Given Name			<u>YAMANAKA</u> Middle Name		<u>YAMANAKA</u> Family Name	
14b	Inventor's Signature	<u>Ryutaro</u>			<u>Yamanaka</u>			
15b	Date of Signature	<u>May</u> Month			<u>25</u> Day		<u>2001</u> Year	
16b	Residence	<u>Yokohama-shi</u> City			<u>Kanagawa</u> State or Province		<u>JAPAN</u> Country	
17b	Citizenship	<u>JAPAN</u>						
18b	Post Office Address (Insert complete mailing address, including country)	<u>1-33-15-201, Kamiookahigashi, Konan-ku,</u> <u>Yokohama-shi, Kanagawa 233-0001 JAPAN</u>						
13c	Typewritten Full Name of Sole or First Inventor							
14c	Inventor's Signature							
15c	Date of Signature							
16c	Residence							
17c	Citizenship							
18c	Post Office Address (Insert complete mailing address, including country)							
13d	Typewritten Full Name of Sole or First Inventor							
14d	Inventor's Signature							
15d	Date of Signature							
16d	Residence							
17d	Citizenship							
18d	Post Office Address (Insert complete mailing address, including country)							